HAWAII PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 43*

Second Progress Report
1 July 2001 through 30 September 2001

Hydrometeorological Design Studies Center
Hydrology Laboratory

Office of Hydrologic Development
U.S. National Weather Service
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DISCLAIMER

The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency analysis for the Hawaii. Current precipitation frequency studies for Hawaii are contained in *Technical Paper No. 43,* "Rainfall-Frequency Atlas of the Hawaiian Islands for Areas to 200 Square Miles, Durations to 24 Hours, and Return Periods from 1 to 100 Years" (U.S. Weather Bureau 1962). The update includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual and seasonal precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Hawaii study area and use accepted statistical methods. The study results will be published as a Volume of NOAA Atlas 14. They will also be made available on the internet using web pages with the ability to download digital files.

The study area covers the Hawaiian islands including Hawaii, Maui, Kahoolawe, Lanai, Molokai, Oahu, Kauai and Niihau. The study area including preliminary regions is shown in Figure 1.

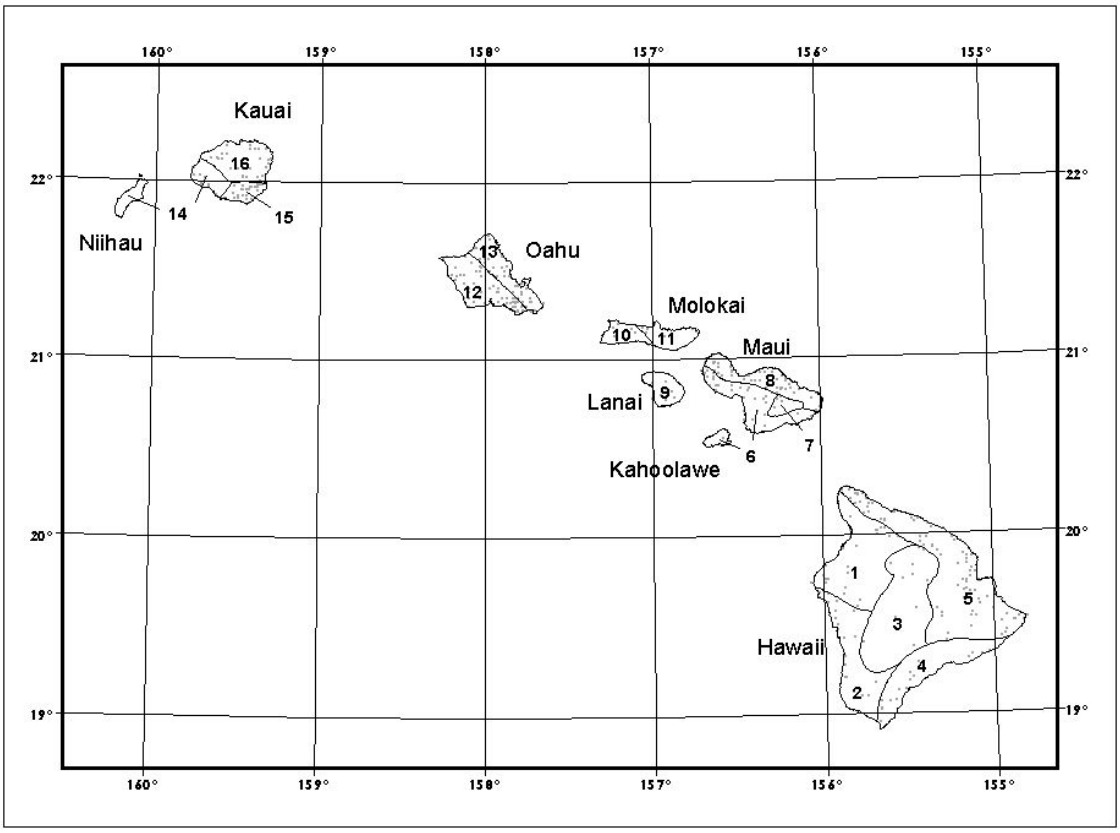

Figure 1. Hawaii Precipitation Frequency study area, regions and Daily station locations.

2. Highlights.

Significant progress was made regarding the technology review the HDSC initiated in the previous reporting period (First Progress Report for the Hawaii Precipitation Frequency Study, August 2001; Section 5, Issues). The HDSC has refined a well-developed and efficient set of procedures for data collection and quality control. In an L-moment Applications Working Group, a panel of 3 independent experts confirmed our current statistical analysis procedures with suggested modifications. Discussions held between the HDSC and the Spatial Climate Analysis Center determined that it is highly likely that Parameter-elevation Regressions on Independent Slopes Model (PRISM) technology can and will be adapted for precipitation frequency studies. Additional information is provided in Section 4.5, Update of Technology Review

Hand entry from paper forms has been completed for years not covered by the National Climatic Data Center (NCDC) digital data set. Additional information on this topic is provided in Section 4.1, Data Collection and Quality Control.

A clear agreement has been established between the HDSC and the other funding agencies to wait for the University of Hawaii to manually digitize archived daily rainfall data from a network of state maintained gauges before proceeding with the HDSC study. Additional information on this topic is provided in Section 4.1, Data Collection and Quality Control.

Work on the Internet-based Precipitation Frequency Data Server has continued. In particular, areal calculation of precipitation frequencies has been modified to allow user-entered longitude/latitude points to establish the size of the area. An improved web page framework has also been developed. The Precipitation Frequency Data Server will accommodate future studies including the Hawaii study. Additional information is provided in Section 4.3, Update of the Precipitation Frequency Data Server.

A detailed outline for NOAA Atlas 14 has been written. It itemizes each theme and estimates the length of each section in the final document. Additional information is provided in Section 4.5, Update of Final Report.

3. Status.

3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percentage completed per task. Past status reports should also be referenced for additional information.

Hawaii study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [25%]:

- Daily
- Hourly
- N-minute

L-Moment Analysis/Frequency Distribution for 5 minute to 60 days and 2 to 1000 yrs [0%]:

- Daily
- Hourly
- N-minute

Algorithm/Data Plot [5%]

- Establish regions from spatial, topographic and meteorological variables
- Run L-moments for regional growth factors to generate dataset
- Create 2yr-24hr precipitation frequency index map using PRISM
- Create ratio maps - 2yr (1-12) hr/2yr 24hr, 2yr (2-60) day/2yr 24hr
  - Plotting
  - Review hand-drawn analysis
  - Perform digitization
  - Rasterization
- Create regional growth factor maps - (5-100) yr (1-12) hr, (5-100) yr 24hr, (5-100) yr (2-60) day

Precipitation Frequency Maps [0%]

- Create frequency maps for 1-hour to 60-day durations at return periods 2 to 1000 years (seasonal and annual maximum) by multiplying index map rasters and using appropriate regional growth factor and ratio map rasters
- Create maps and/or relations for durations smaller than 1 hour (5, 10, 15, 30 minute) using index map and appropriate conversion factors
- Perform internal consistency checks (comparing rasters of sequential duration and frequency)

Data Trend Analysis [0%]
- Analyze linear trends in annual maximums and variance over time
- Analyze shift in means of annual maximums between two time periods (i.e., test the equality of 2 population distribution means)

Seasonal Analysis [0%]
- Create graphs of percentage of precipitation maximums in each month of a year

Temporal Distributions of Extreme Rainfall [0%]
- hourly data assembled by quartile of greatest precipitation amount and converted to cumulative rainfall amounts for each region
- graphs of representative storm-types and seasons

Spatial Relations (Depth-Area-Duration Studies) [0%]
- analyze critical storms to determine depth-area-duration relations
- small-area, short-duration relations
- area-depth curves for areas <500 mi^2 and for >500mi^2
- families of mass curves and area-depth curves as a function of duration and area size
- a smoothed set of curves to distinguish between convective, tropical and non-tropical storms (if appropriate)

Deliverables [5%]
- Write hard copy of Final Report
    - Maps of analyzed results
    - Graphical relations to obtain intermediate values
    - Seasonal variation
    - Depth-area distribution
    - Temporal distribution of rainfall in extreme storms
    - Implement peer review and interagency review
- Prepare data for web delivery
- Prepare documentation for web delivery
- Publish hard copy of Final Report

3.1.1 Data Collection and Quality Control.

The University of Hawaii will be digitizing daily data from a network of state operated gauges. Once this data is added to our dataset the number of daily stations will greatly increase.

The NCDC daily and hourly datasets have been updated through December 1999 and the n-minute dataset through May 1997. When we receive the completed digitized state dataset from the University of Hawaii we will update our database with all available NCDC data.

3.1.2 Mapping Analyses.

The HDSC continues to explore the possibility of using spatial interpolation tools such as the Parameter-elevation Regressions on Independent Slopes Model (PRISM). Discussions with the Spatial Climate Analysis Center have determined that, with the establishment of additional criteria, PRISM technology may be adapted to precipitation frequency data.

3.1.3 Documentation and Publication.

The Hawaii study results will be available on the HDSC Precipitation Frequency Data Server once mapping is complete and reviewed. The Data Server displays precipitation frequency values and intensity-duration-frequency curves and tables. The Server is currently password protected and not publicly available. At present, all 50 states can be selected. Where studies are not yet concluded, such as Hawaii, information on existing precipitation frequency maps, namely Technical Paper No. 43 (U.S. Weather Bureau 1962) is given.

3.1.4 Trend and Shift Analyses.

Annual maxima will be analyzed for statistical trends and shifts using software developed by the HDSC once the dataset is complete.

4. Progress in this Reporting Period.

4.1 Data Collection and Quality Control

To increase the record length of the NCDC digital daily data, hand-entry of data was done. NCDC digital records began around 1949 while data recorded on paper begins before 1900 for some stations. This has added 40 or more years to some daily stations.

A clear agreement has been established between the HDSC, the Hawaii Department of Land and Natural Resources, the US Army Corps of Engineers and the University of Hawaii to wait for the University to manually digitize daily rainfall data from the paper archives of a network of state maintained rain gauges. This data will greatly enhance the spacial resolution of our dataset. By request of the funding agencies, the current plan is to digitize data from the Big Island of Hawaii first and produce preliminary precipitation frequency maps for the Island, then digitize data from the remaining islands. The current estimation from the University is the data entry for all the Islands will take 6 months to one year, causing a delay of the same length to the project as we wait for the data.

The HDSC has defined a well-developed and efficient set of procedures for data collection and quality control. The procedures have been refined over time for extracting and quality controlling data from the National Climatic Data Center. The procedures and data formats are structured to fit efficiently into sequential processes for producing updated rainfall frequency estimates. We plan to continue using these procedures. The HDSC plans to publish the final quality-controlled time series used in its analysis.

4.2 Mapping

Digital maps of elevation were obtained and printed for use in future analyses for this study. Maps of station location were also plotted. These station locations and elevations were checked to be sure the databases were correct and matched each other. Station locations were also scrutinized to determine where supplemental State gage information would help the spatial distribution.

4.3 Update of Precipitation Frequency Data Server

The Internet-based Precipitation Frequency Data Server (PFDS) continues to be developed, tested and enhanced. Most importantly, the areal calculation functionality has been modified to be more flexible and accurate. Unlike previous beta versions, the PFDS now uses a list of user-entered longitude/latitude points to calculate the area size and precipitation frequency estimates. Originally it was feared that the

areal-calculations would require an unacceptable amount of time to compute, but with the new modifications, the calculation time is very fast.

Another important PFDS modification has been the initial development of a new web page framework. The new framework will better accommodate such items as Help, General Information, Feedback, Files for Downloading, Background Information, and Contact Information. The new framework will include a PFDS Users Guide as well as an on-line NOAA Atlas 14 Mini-Manual.

4.4 Final Report

A detailed outline for NOAA Atlas 14 has been written. It itemizes each theme and estimates the length of each section in the final document. The format of NOAA Atlas 14 will be similar to NOAA Atlas 2 but also include explicit references regarding the L-moment procedure for estimating precipitation frequency.

4.5 Technology Review

We have made significant progress on the technology review we initiated in the previous reporting period. (See First Progress Report for the Hawaii Precipitation Frequency Study, August 2001; Section 5, Issues.)

4.5.1 Statistical Analysis

Based on recommendations during the previous quarter by independent experts, in this quarter we held detailed face to face discussions with David Goldman (U.S. Army Corps of Engineers), Ned Guttman (NOAA, National Climatic Data Center), and John Hosking (IBM). The discussions confirmed our general plan to use the statistical procedures described in *Regional Frequency Analysis: An Approach Based on L-Moments*, Hosking and Wallis, 1997. In their book, Hosking and Wallis discuss possible variations in specific procedures. HDSC will document and publish the specific choices we made between possible alternatives. We have also decided to adopt the procedures described by Hosking and Wallis for assessing the accuracy of estimated values.

The HDSC will use the *unbiased plotting-position estimators* unless we can demonstrate that careful use of the *biased plotting-position estimators* is more effective. During the next quarter we will conduct an assessment of the biased estimators. We do not expect this assessment to impact our schedule

4.5.2 Spatial Interpolation

HDSC held discussions in Corvallis with Oregon State University's Spatial

Climate Analysis Service. In the previous reporting period we mentioned our concerns about legal issues relating to the use of their PRISM technology. Discussions suggest that these legal issues can be overcome. While PRISM has been accepted for spatial interpolation of other climatic parameters, it has not been proven in the analysis of rainfall intensity frequency duration estimates. Technical discussions and more detailed demonstrations of PRISM capabilities have convinced us that it is highly likely we will be able to use PRISM for spatial interpolation of the point estimates derived from regional analysis using L-moments. As a result, HDSC has entered into detailed discussions with the Spatial Climate Analysis Service to first conduct a final proof test of PRISM technology and then use the technology in our production process.

5. Issues.

5.1 Personnel

Dr. Lesley Julian has announced her retirement effective September 30 2001. Dr. Julian was a full time Federal Government employee and we have begun the process of seeking a replacement. Mr. Geoffrey Bonnin is now directly managing the HDSC.

6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on in the next quarter are also included in this section. The University of Hawaii Digitizing completion date is indicated as Month Zero (M_0).

Data Collection and Quality Control [M_0 + 3 months]
L-Moment Analysis/Frequency Distribution [M_0 + 5 months]
Algorithm/Data Plot [M_0 + 6 months]
Precipitation Frequency Maps [M_0 + 7 months]
Temporal Distributions of Extreme Rainfall [M_0 + 8 months]
Trend Analysis [M_0 + 9 months]
Seasonal Analysis [M_0 + 9 months]
Spatial Relations (Depth-Area-Duration Studies) [M_0 + 10 months]
Implement review by peers [M_0 + 11 months]
Write hard copy of Final Report [M_0 + 12 months]
Publish hard copy of Final Report [M_0 + 13 months]

6.1 Data Collection and Quality Control.

A clear agreement has been established between the HDSC and the other funding agencies to wait for the University of Hawaii to manually digitize daily rainfall data from a network of state maintained rain gauges. The current estimation from the University is the data entry will take 6 months to one year, causing a delay of the same length to the project as we wait for the data. This delay is reflected in the above projected schedule.

6.2 Precipitation Frequency Maps.

A sophisticated cartographic-map making process has been designed using the recently released GIS software, ArcView 8.1. During the next few months a review and revision process will result in a final cartographic-quality map template. This map template will then serve as the basis for all future precipitation frequency maps. The maps will be available online as postscript, ArcInfo ASCII raster, ArcView Shape, and JPEG files. The maps will also be made available in a hardcopy form as a Volume of NOAA Atlas 14.

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